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Terahertz light emission and lasing in current-injection graphene-channel transistors

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Graphene has attracted considerable attention due to its massless and gapless energy spectrum. We designed and fabricated our original distributed-feedback dual-gate graphene-channel field-effect transistor (DFB-DG-GFET). The DG-GFET structure serves carrier population inversion in the lateral p-i-n junctions under complementary dual-gate ($V_{g1,2}$) biased and forward drain-source (V_d) biased conditions, promoting spontaneous broadband incoherent THz light emission. The tooth-brush-shaped DG forms the DFB cavity having the fundamental mode at 4.96 THz, which can transcend the incoherent broadband LED to the single-mode lasing action. The GFET channel consists of a few layer (non-Bernal) highest-quality epitaxial graphene, providing an intrinsic field-effect mobility exceeding 100,000 cm^2/Vs . Fourier-transform far-infrared spectroscopy revealed the THz emission spectra for the fabricated samples under population inversion conditions; one sample exhibited a 1-7.6-THz broadband, rather intense ($\sim 80 \mu\text{W}$) amplified spontaneous emission and the other sample did a weak ($\sim 0.1 \mu\text{W}$) single mode lasing at 5.2 THz both at 100K. Introduction of the graphene plasmonics in vdW 2D heterostructures is a key to increase the operating temperature and radiation intensity. Asymmetric dual-grating-gate metasurface structures may promote plasmonic superradiance and/or plasmonic instabilities, giving rise to giant THz gain enhancement at plasmonic resonant frequencies. Further improvement will be given by a gated double-graphene-layer (G-DGL) nanocapacitor vdW 2D heterostructures. Exploitation of the graphene plasmonics in vdW 2D heterostructures will be the key to realize room-temperature, intense THz lasing.

Biography

Taiichi Otsuji received the Doctorate, Engineering degree from Tokyo Institute of Technology, Japan in 1994. He has been a professor at RIEC, Tohoku University, Japan since 2005 after working for Kyushu Institute of Technology (1999-2005) and NTT Laboratories (1984-1999), Japan. He is authored and co-authored 250 peer-reviewed journals. He was awarded the Outstanding Paper Award of the 1997 IEEE GaAs IC Symposium, and has been served as an IEEE Electron Device Society Distinguished Lecturer since 2013. He is a Fellow of the IEEE, a senior member of the OSA, and a member of the MRS, SPIE, JSAP, and IEICE.

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